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ノート（Note）

Comparison of forest carbon stocks between canopy conditions in two typical dipterocarp forest types in Peninsular Malaysia

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半島マレーシアの典型的な２つのフタバガキ林における林冠状態の違いによる炭素蓄積量の比較

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Key words: aboveground biomass, canopy gaps, tropical rain forests, REDD

REDD+ (“Reducing Emissions from Deforestation and Forest Degradation and the Role of Conservation, Sustainable Management of Forests and Enhancement of Forest Carbon Stocks in Developing Countries”) is a key strategy in mitigating climate change. Because the implementation of REDD+ depends on the measurement of forest carbon stocks, long-term monitoring of forest dynamics can facilitate the accurate estimation of changes in stocks. To investigate temporal and spatial changes in carbon stocks, we estimated aboveground biomass using tree census data collected at long-term ecological research sites in Peninsular Malaysia. Here, we report changes in aboveground biomass under different canopy conditions in two typical dipterocarp forests.

Since 1992, we have been studying forest dynamics in two 6-ha plots in Peninsular Malaysia (Fig. S1). The Semangkok plot (3º40’N, 101º40’E) is a hill dipterocarp forest dominated by *Shorea curtisii* (Niiyama et al. 1999). The Pasoh plot (2º58’N, 102º18’E) is a lowland dipterocarp forest (Hoshizaki et al. 2004). In 2011, we censused canopy gaps in both plots. Each plot was gridded into 2400 5-m × 5-m quadrats. A canopy gap was defined as a quadrat having a maximum canopy height of <10 m (Fig. S2a). To compare biomass between closed canopy and gaps, we estimated aboveground biomass in 150 20-m × 20-m subplots in each plot, each comprising 16 quadrats. The canopy condition of each subplot was designated according to the number of gap quadrats (Fig. S2b) as Gap class (≥9 gap quadrats), Closed_low class (5–8), or Closed_high class (≤4). All trees with a diameter at breast height (DBH) of >5 cm were censused in 2000 and 2010 at Pasoh and in 2001 and 2011 at Semangkok. The aboveground biomass was calculated from the tree census data with allometric equations developed by Kato et al. (1978).

Nearly 15% of quadrats were in the Gap class in both plots (Fig. S3). Neither plot had been disturbed in the 10 years (e.g. fire and wind storm), and the overall tree mortality rate was around 2% year^{-1}. Aboveground biomass decreased as the number of gap quadrats increased (Fig. 1). Differences among the categories were smaller in Pasoh than in Semangkok (Fig. 1). In Semangkok, the density of trees of ≥90 cm DBH was relatively high in the Closed_high class (Fig. 2a), and the change in the density of these trees was responsible for the change in aboveground biomass, especially in the Gap class (Fig. 2c, Table 1). Aboveground biomass in the Closed_high class was smaller in Pasoh than in Semangkok (Fig. 1), owing to a lower density of large-diameter trees (i.e. DBH > 90 cm) (Figs. 2a and 2d). Moreover, increases in density of trees of 50–90 cm DBH in the Closed_low class increased biomass, while mortality in the Gap class decreased biomass (Figs. 2e and 2f, Table 1).

Table 1. Mean annual increment of aboveground biomass (Mg ha^{-1} year^{-1}) between three canopy condition categories. These values were calculated using the 10-years period data from 2001 to 2011 at Semangkok and from 2000 to 2010 at Pasoh. Values within parentheses indicate the standard error of each class.

Canopy condition categories	Number of gap quadrat	Semangkok		Pasoh	
Closed_high class	0 - 4	2.47	(1.00)	0.72	(1.73)
Closed_low class	5 - 8	-8.15	(4.71)	4.08	(0.89)
Gap class	9 - 16	-15.79	(14.89)	-3.10	(5.63)

Thus, differences in stand size-structure, especially with large-diameter tree density, cause fluctuations in forest carbon stocks. Our results suggest that monitoring of stand structure and the distribution of canopy gaps are important to understanding forest carbon dynamics and could provide basic information for forest carbon monitoring system under REDD+.

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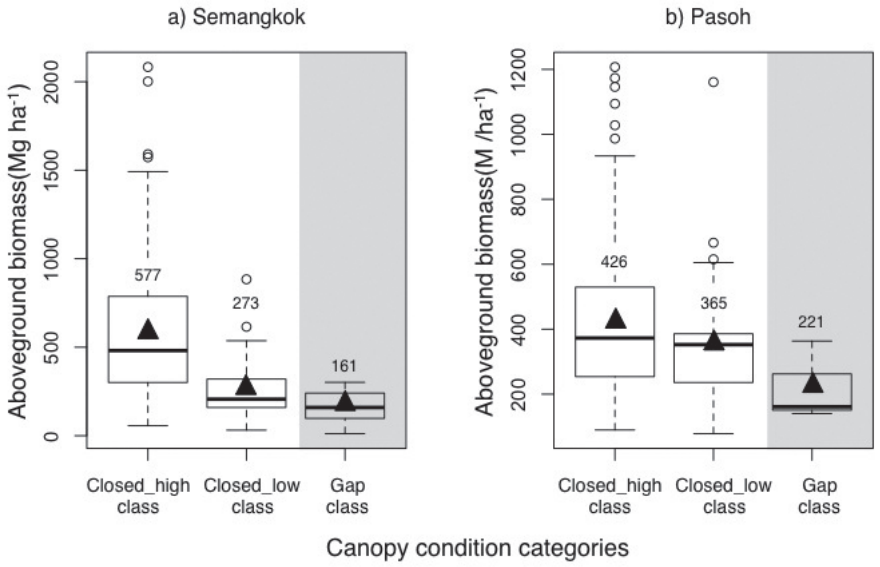

Fig. 1. Changes in aboveground biomass between three canopy condition categories. Aboveground biomass were calculated using tree census data in 2011 at Semangkok and 2010 at Pasoh. The center bar in the box denotes the median of aboveground biomass; upper and lower bars represent the 75th and 25th percentile, respectively; vertical dash lines connect the 90th and 10th percentile values; the closed triangle shows the average.

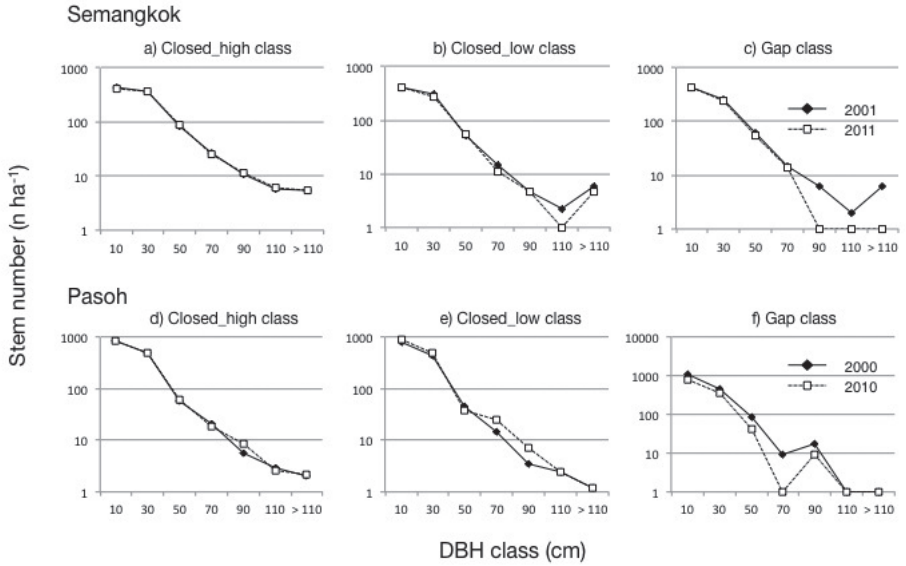

Fig. 2. Comparison of stem density in each DBH class among canopy conditions.

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Supplemental materials

Additional supplemental materials are provided in the online version.

Fig. S1. Locations of the plots.

Fig. S2. Definitions of canopy gap on the basis of vertical profile and spatial profile.

Fig. S3. Spatial distribution of canopy gaps in the plots.

URL : http://www.ffpri.affrc.go.jp/pubs/bulletin/429/documents/429-x.pdf

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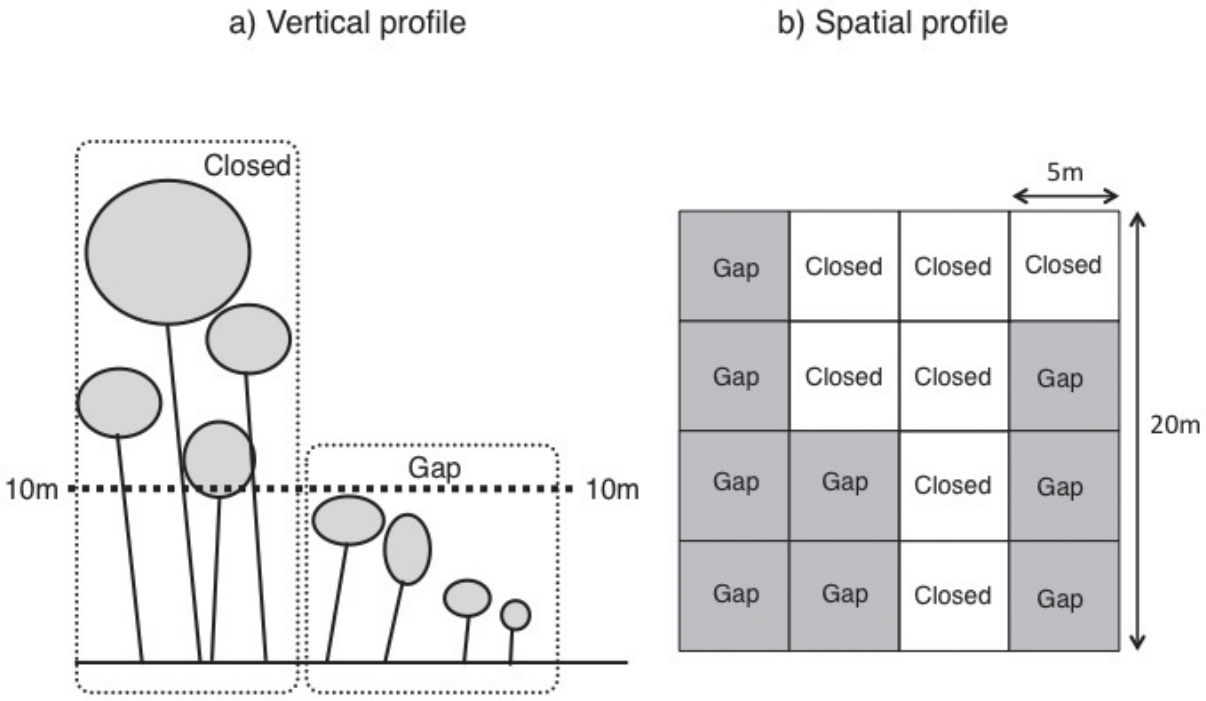

Fig. S2. Definitions of canopy gap on the basis of vertical profile (a) and spatial profile (b). In this example, this subplot is judged as Gap as it has 9 "gap" quadrats

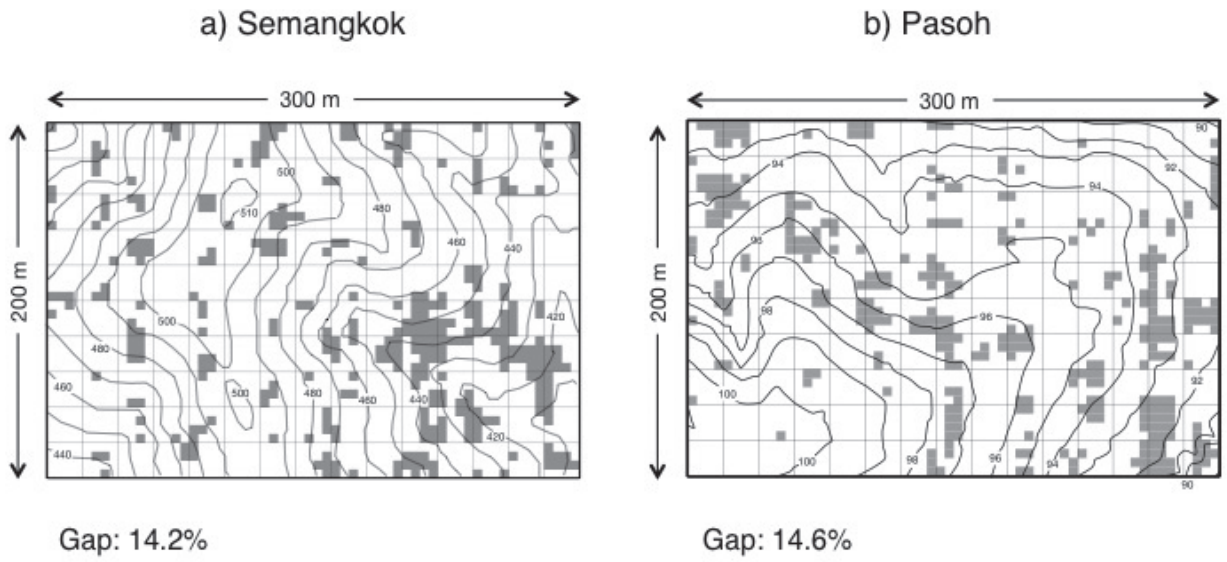

Fig. S3. Spatial distribution of canopy gaps in the plots. Grey parts show quadrats judged as "gap" . Contour interval is 10 m in Semangkok and 1 m in Pasoh.